Reference condition for Great Rivers: Concepts and results of data exploration

Ted Angradi and David Bolgrien, US EPA

Survey of Nation's Rivers
Planning Meeting
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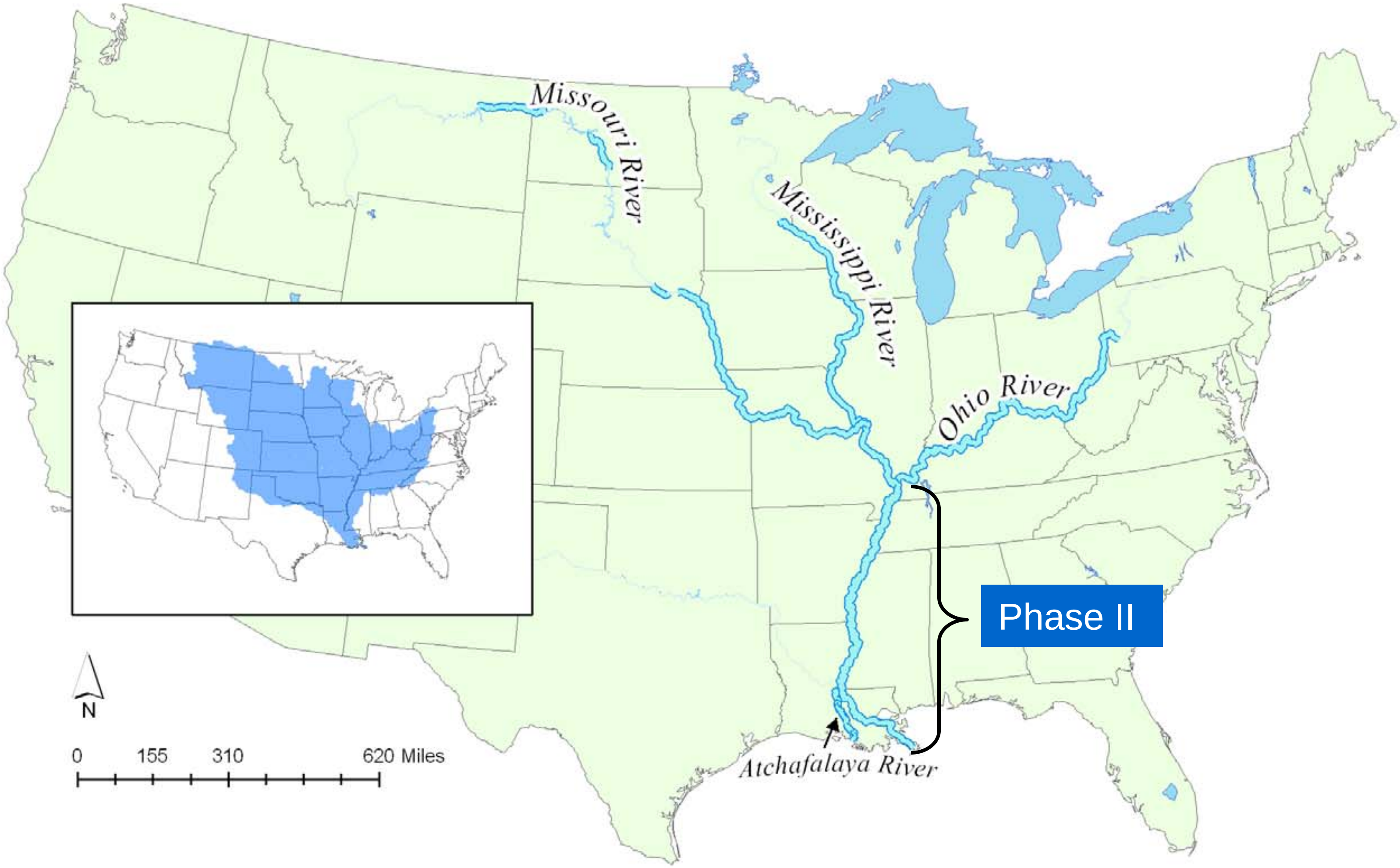
- EMAP-Great River Ecosystems basics
- Least disturbed condition and the EMAP-GRE assessment
- Stratification of reference condition
- Stressor metrics useful for screening
- Approaches to screening

EMAP-GRE

Our objective is to **develop, demonstrate, and transfer** bioassessment methods for Great River ecosystems of the Mississippi River Basin

- July-Sept 2004-2006 sampling
- About 475 sites
- 10 crews; ≥100 people directly involved from at least 15 agencies
- 8 biotic assemblages, water chem, phab
- Published field operations manual available
  http://www.epa.gov/emap/greatriver/fom.html

Scope of EMAP-GRE



EMAP-GRE vs. The National River Survey

- Very different design: EMAP-GRE includes only 3 rivers total
- EMAP-GRE is committed to state-scale reporting units
- Sample size >100 for each river
- 1 km sample reach (not based on WW)
- Targeted sampling (for reference) integrated into the probability design (almost no direct BPJ)
- EMAP-GRE is research (takes some risks)

A common perception

The Great Rivers of the Mississippi River Basin are commercial/industrial rivers with a long history of human use and disturbance. Therefore, a reference condition based on any current conditions is problematic.

The assumption

"Regardless of the extent of human disturbance in a region, some stream sites will have less human disturbance than others and these yield the best existing [least disturbed] conditions"

Stoddard et al. 2006

The logic of internal reference

"[On] large rivers, reference sites may be upstream of major sources of disturbance or as far as possible from upstream sources, cities, and dams"

Hughes 1995

The hope

Least disturbed condition based on internal least disturbed sites are an appropriate benchmark for assessment of the Great Rivers that is consistent with CWA goals

based on language in EPA-260-F-06-002: Best practices for identifying reference condition in Mid-Atlantic streams

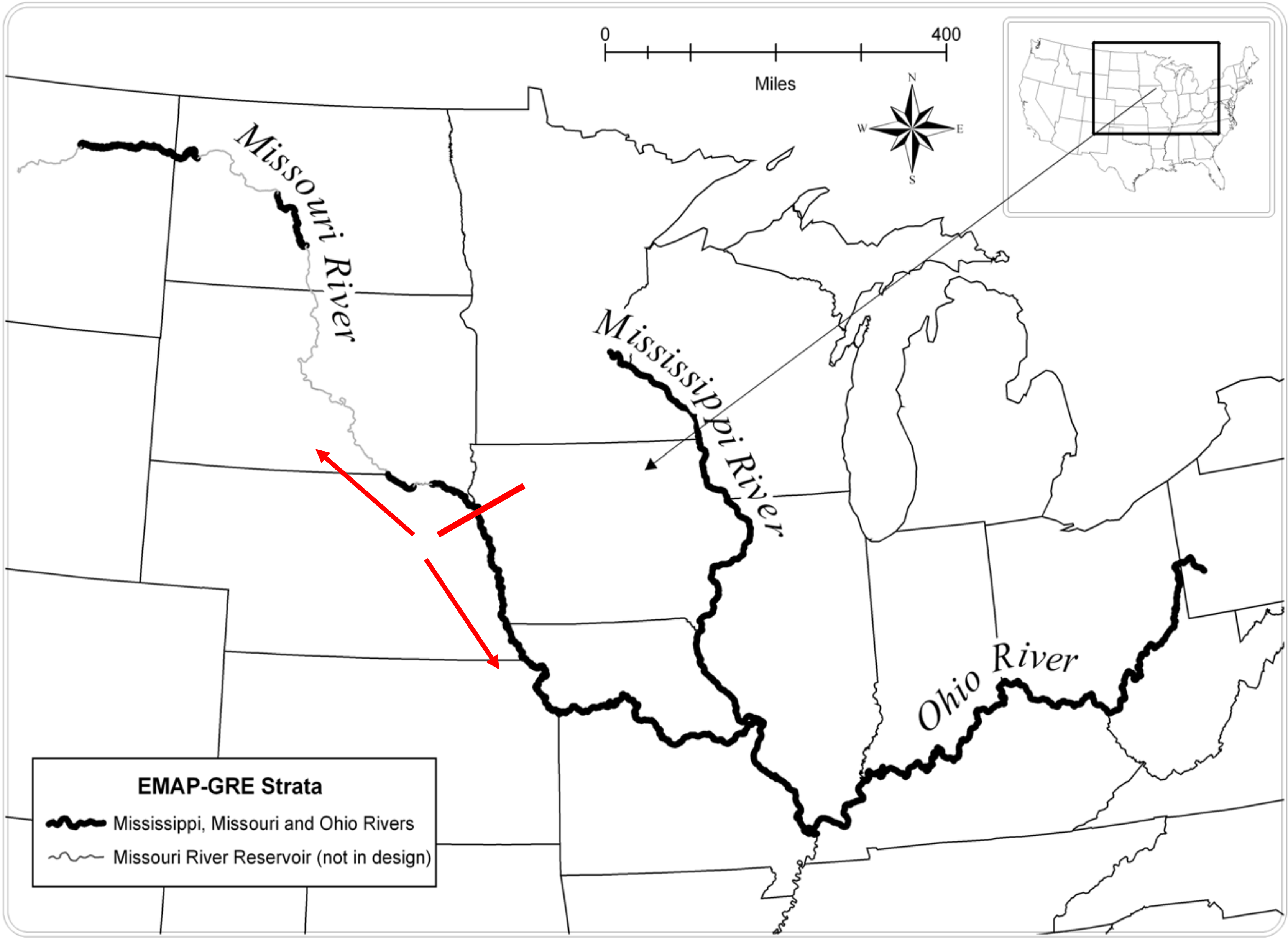
Stratification of reference condition and the assessment

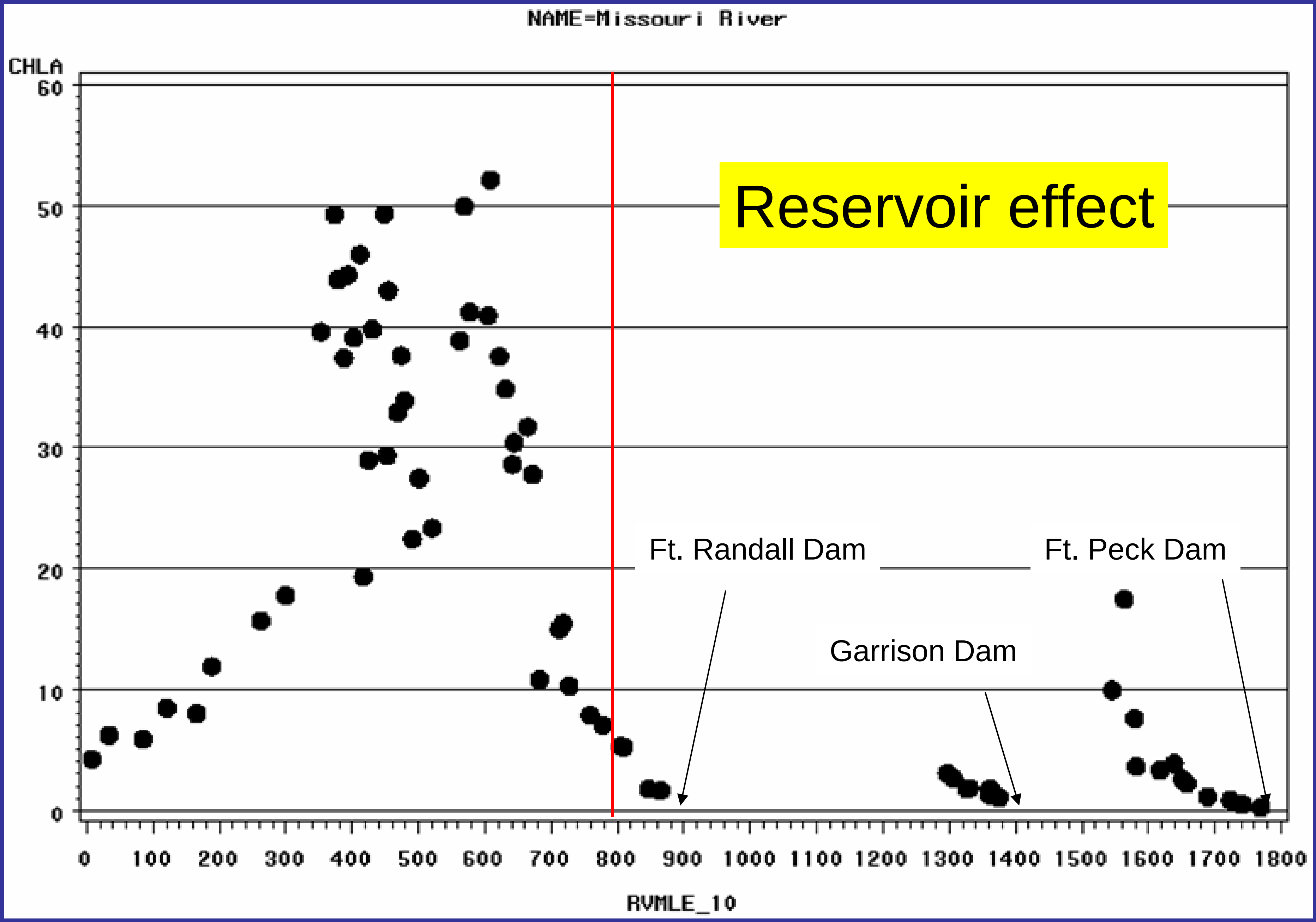
- Stratification = different set of reference sites for different reaches or aquatic habitats.
- Geographic stratification will influence the condition assessments because there are almost certainly longitudinal patterns in condition.

Example: geographic stratification of Missouri River

- Large differences in the natural setting between the Upper and Lower Missouri River
- Upper River strongly influenced by “permanent” large deep-release reservoirs. Also, different channel management regime and much more arid climate

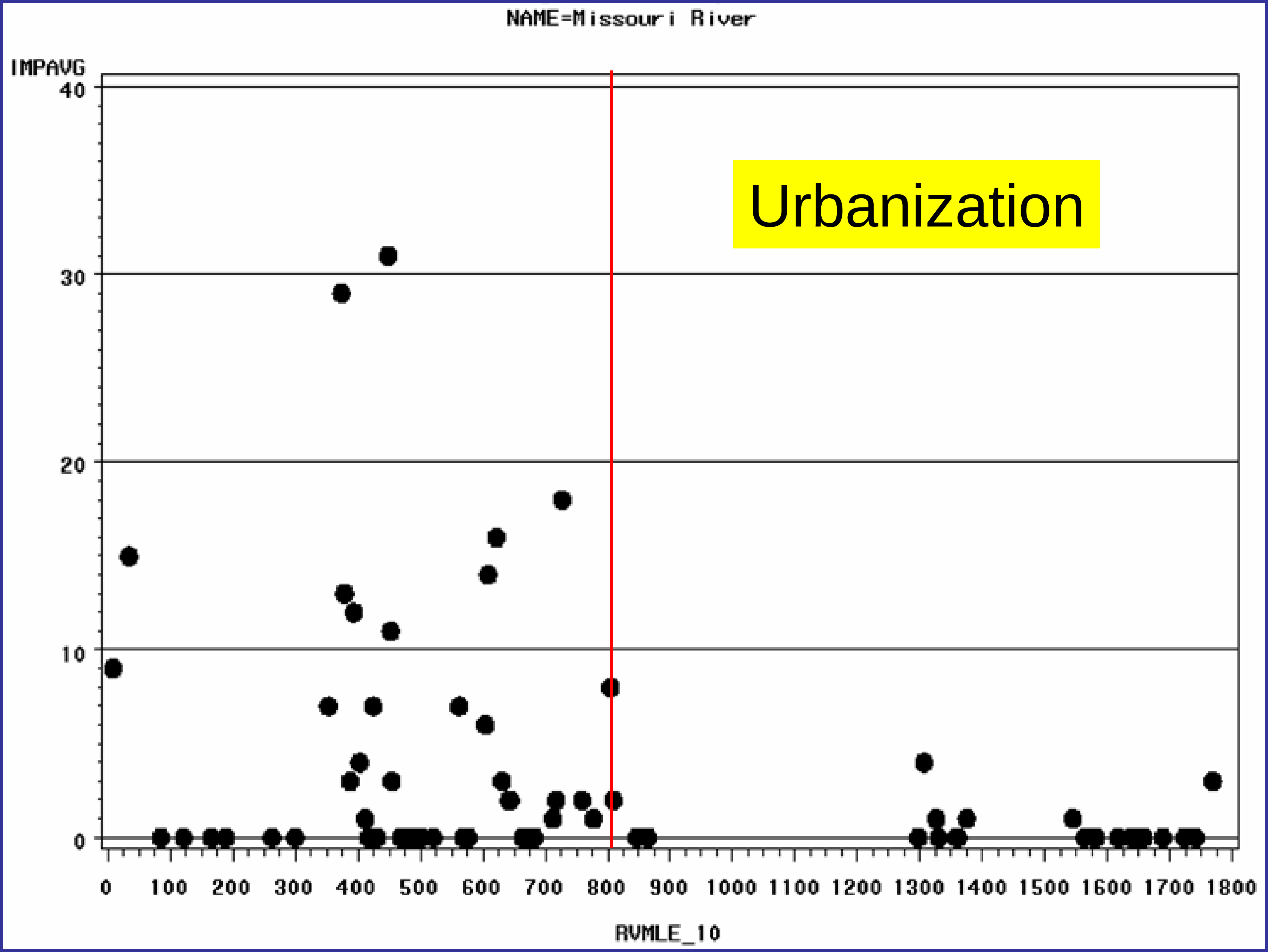
Upper vs Lower Missouri River




NAME=Missouri River
CHLA
60
50
40
30
20
10
0
Reservoir effect
Ft. Randall Dam
Ft. Peck Dam
Garrison Dam
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800
RVMLE_10

Consequences of not stratifying LDC on Missouri River

- Upper river sites would be over-represented in reference set if not stratified because most stressor indicator values are lower on upper river.
- But these sites are not really in LDC relative to the lower river because of the dams and multiple related effects
- Assessing the lower river using (mostly) upper river reference criteria would be a tough sell to states


NAME=Missouri River
IMPAVG
40
30
20
10
0
Urbanization
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800
RVMLE_10

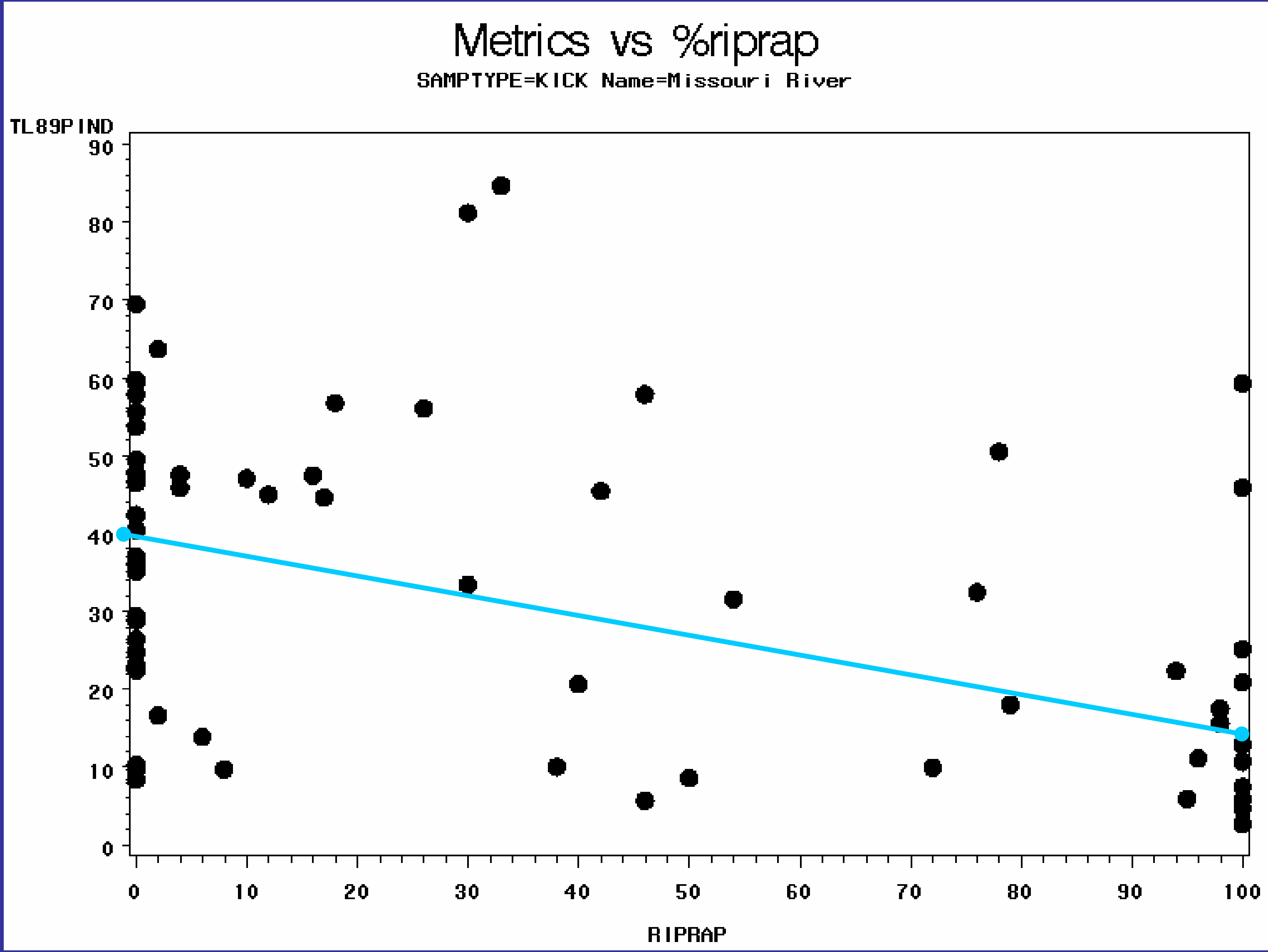
Habitat stratification

Variation among widespread
and "permanent" aquatic habitats may be
greater than variation due to other stressors

riprap

"natural"

Significant effect of riprap on the percent pollution tolerant invertebrates...But riprap isn't pollution



Reality check

Habitat stratification may be essential because if we assume riprap is a stressor rather than a habitat strata, then riprap would drive invertebrate indicator development and we would lose sensitivity to other stressors.

=Strong substrate effect may obscure subtle pollution effects

Metrics for screening

We have sampled all the sites and now we need to screen them to identify sites in least disturbed condition

Some of the many available EMAP-GRE stressor/human disturbance metrics

Metric class	**Metric**	**Relationship to condition**
Water chem	Total P	Negative
Water chem	Total N	Negative
Water chem	Sulfate	Negative
Water chem	Chloride	Negative
Water chem	DO	Positive
Water chem	Turbidity	Negative
Water chem	Total dissolved metals	Negative
Exposure	Sedtox (amphipod survival)	Negative
Phab	LWD density (fish habitat)	Positive
Phab	Development score	Positive
Phab	Human influence index	Negative

Screening metrics, cont.

Metric Class	Metric	Relationship to condition
Phab	Riparian disturbance index	Positive
Phab	Vegetative cover index	Positive
Biology	Percent DELT anomalies	Negative
Landscape	Route distance upriver to dam	Positive
Landscape	Route distance upriver to NPDES	Positive
Landscape	Route distance upriver to large trib	Positive
Landscape	Route distance upriver to small trib	Positive
Landscape	Local percent cultivated (5 k radius)	Negative
Landscape	Local percent forest + wetland (5 k radius)	Positive
Landscape	Local impervious surface (5 k radius)	Negative

* Metrics in yellow included in screening examples

Approaches to screening

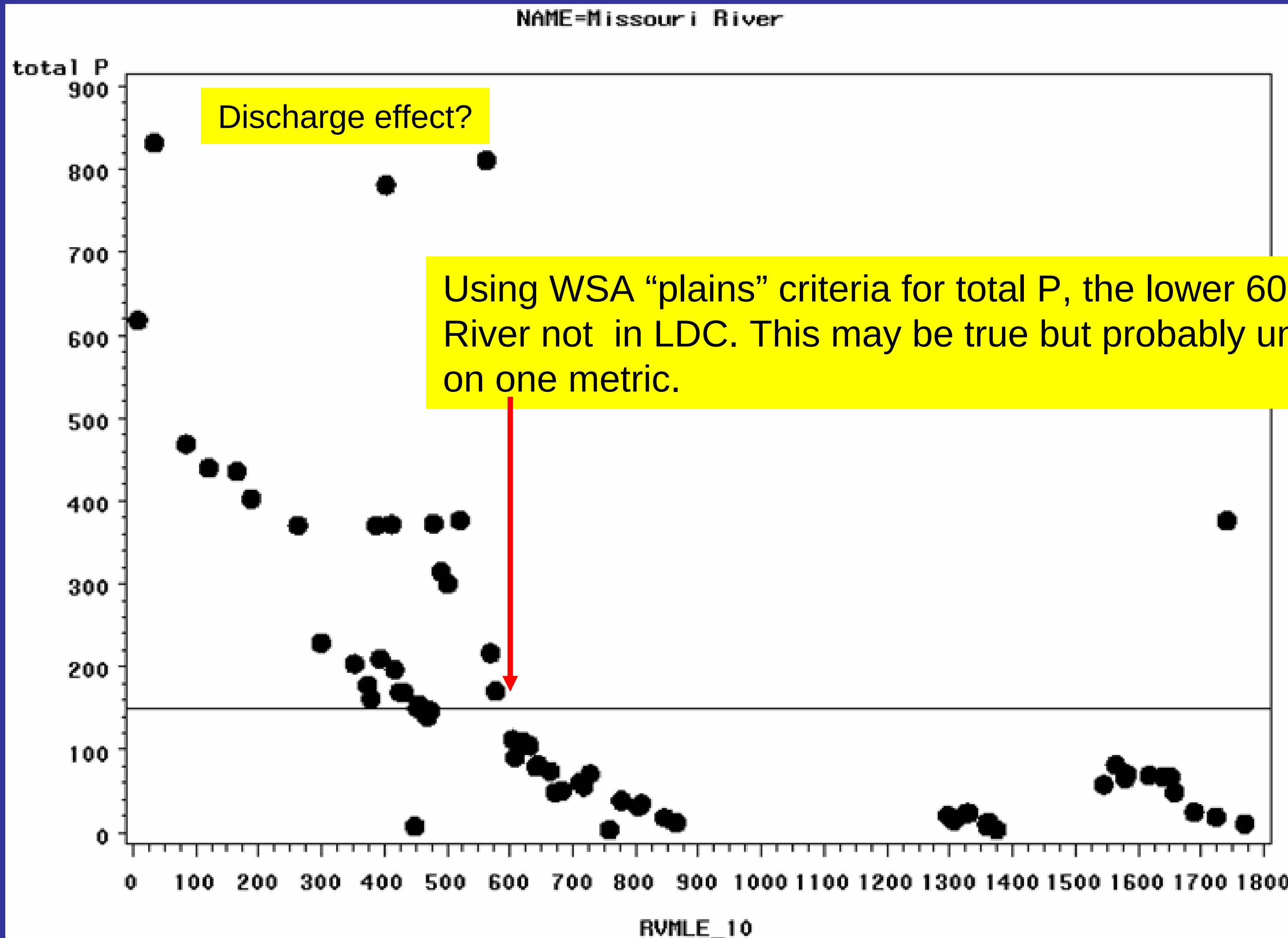
Example of pass/fail screening for wadeable streams

For EMAP wadeable stream datasets, the reference sites are generally screened on chemistry and physical habitat variables with region-specific criteria.

Agg.Region	Corrected Cl	Total P	Total N	Sulfate	Turbidity	pH	% Fines	Rip. Disturbance	Canopy Density
Southwest Mtns	<300 ueq/L	<50 ug/L	<750 ug/L	--	--	<9.0	<15%	<0.5	>50%
Northwest Mtns.	<1000 ueq/L	<50 ug/L	<4500 ug/L	<2000 ueq/L	<50 PCU	<9.0	<50%	<1.5	>50%
So. Rockies	< 200 ueq/L	<25 ug/L	<750 ug/L	<200 ueq/L	--	<9.0	<15%	<1.0	<50%
No. Rockies	< 200 ueq/L	<25 ug/L	<750 ug/L	<200 ueq/L	--	<9.0	<15%	<1.0	<50%
Plains	<1000 ueq/L	<150 ug/L	<4500 ug/L	--	<50 PCU	<9.0	<90%	<2.0	>25%
Xeric	<1000 ueq/L	<50 ug/L	<1500 ug/L	--	<25 PCU	--	<50%	<1.5	>50%

Pass all = reference; fail any = non reference

Simple and proven for smaller streams and lakes



Using WSA "plains" criteria for total P, the lower 600 miles of Missouri River not in LDC. This may be true but probably unwise to base it on one metric.

Pass/fail criteria

- Great River water chemistry metrics confounded by strong longitudinal trends and intra-seasonal flow variation.

- Canopy density and riparian disturbance are likely have weaker local effects on aquatic biota in the Great River setting compared to small streams.

- Percent fines probably not relevant in sand-dominated systems and we don’t have sufficient data to separate out silt-clay from sand-silt.

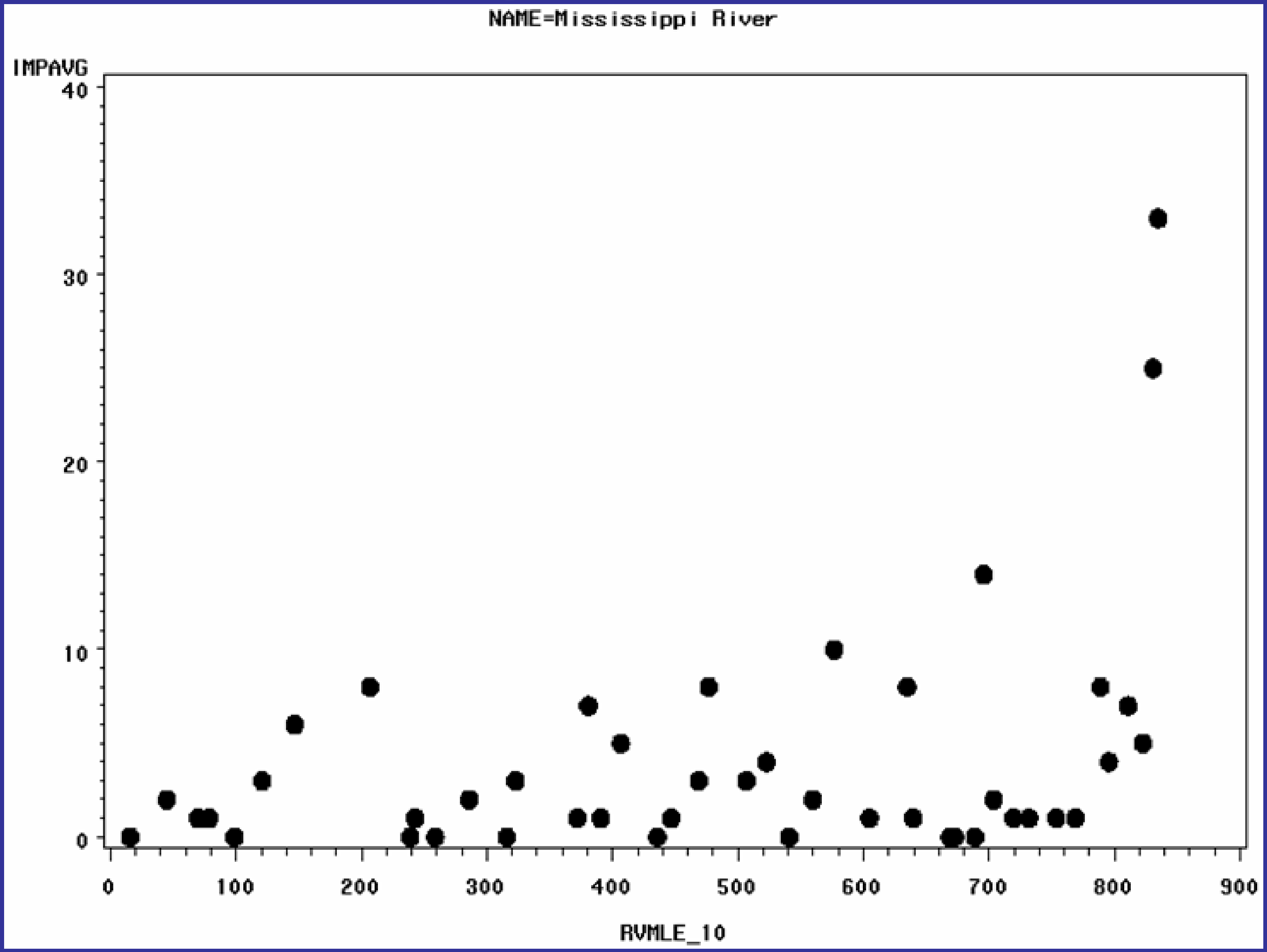
Pass/fail, continued

- Requires expert knowledge to set P/F criteria for each metric; we don’t have that expertise yet
- We will try to adapt the P/F approach to GRE data, but we want to explore other approaches if doesn’t work out
- All screening metrics are flawed so more metrics reduces chances of a misleading result
- Alternative: multimetric approach

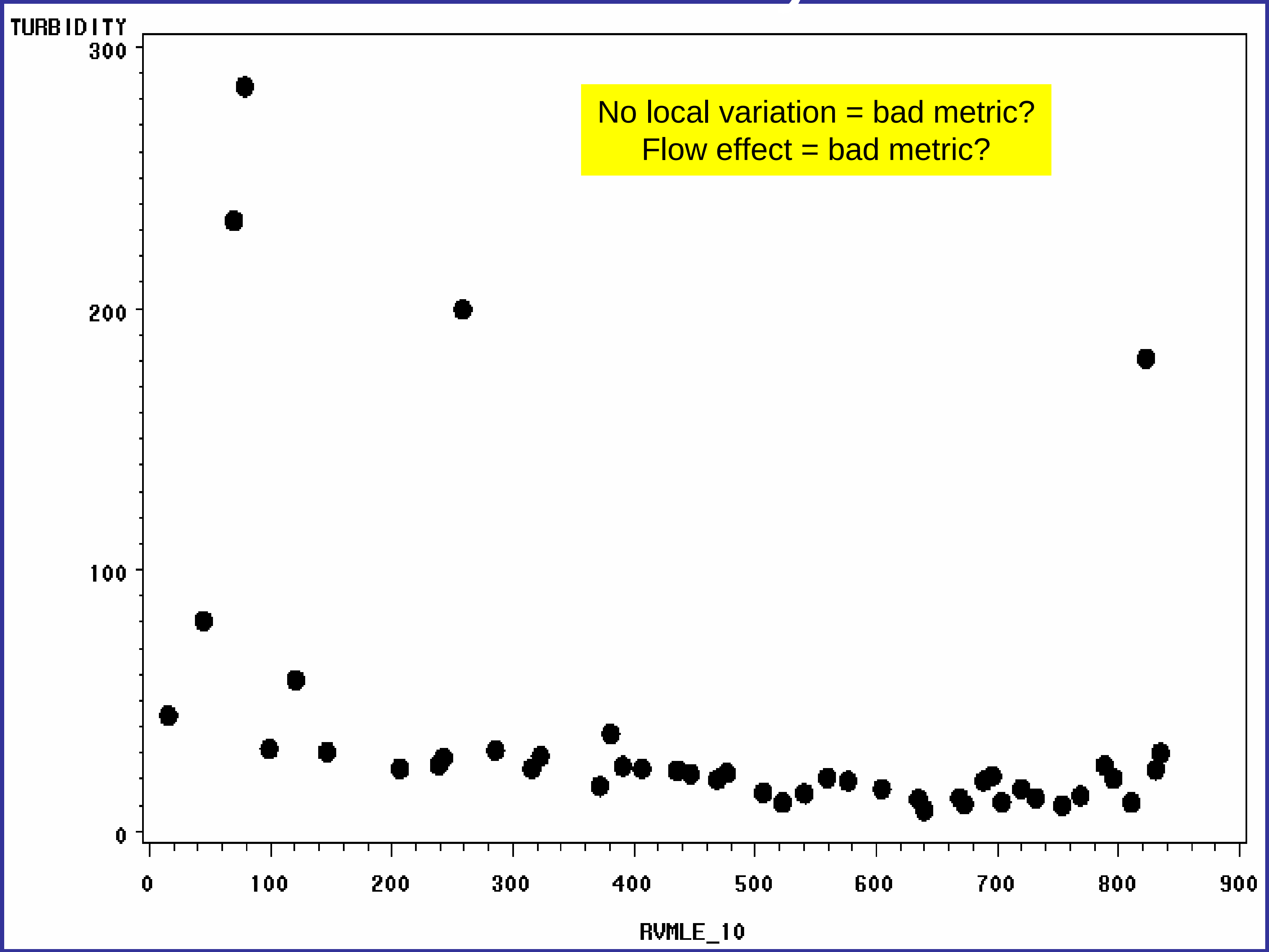
Example: multimetric with continuous scoring (one possible multimetric approach)

- 13 metrics in this example: DO, turbidity, development score, total P, total N, CL, SO_4, dissolved metals, sedtox, % cultivated, % forest+wetland, %impervious surface, LWD density
- Normalize all stressor metrics to 0-1
- Calculate a mean metric score for each site
- $\geq 75^{th}$ pctl of scores = LDC
- $\leq 25^{th}$ pctl of scores = MDC

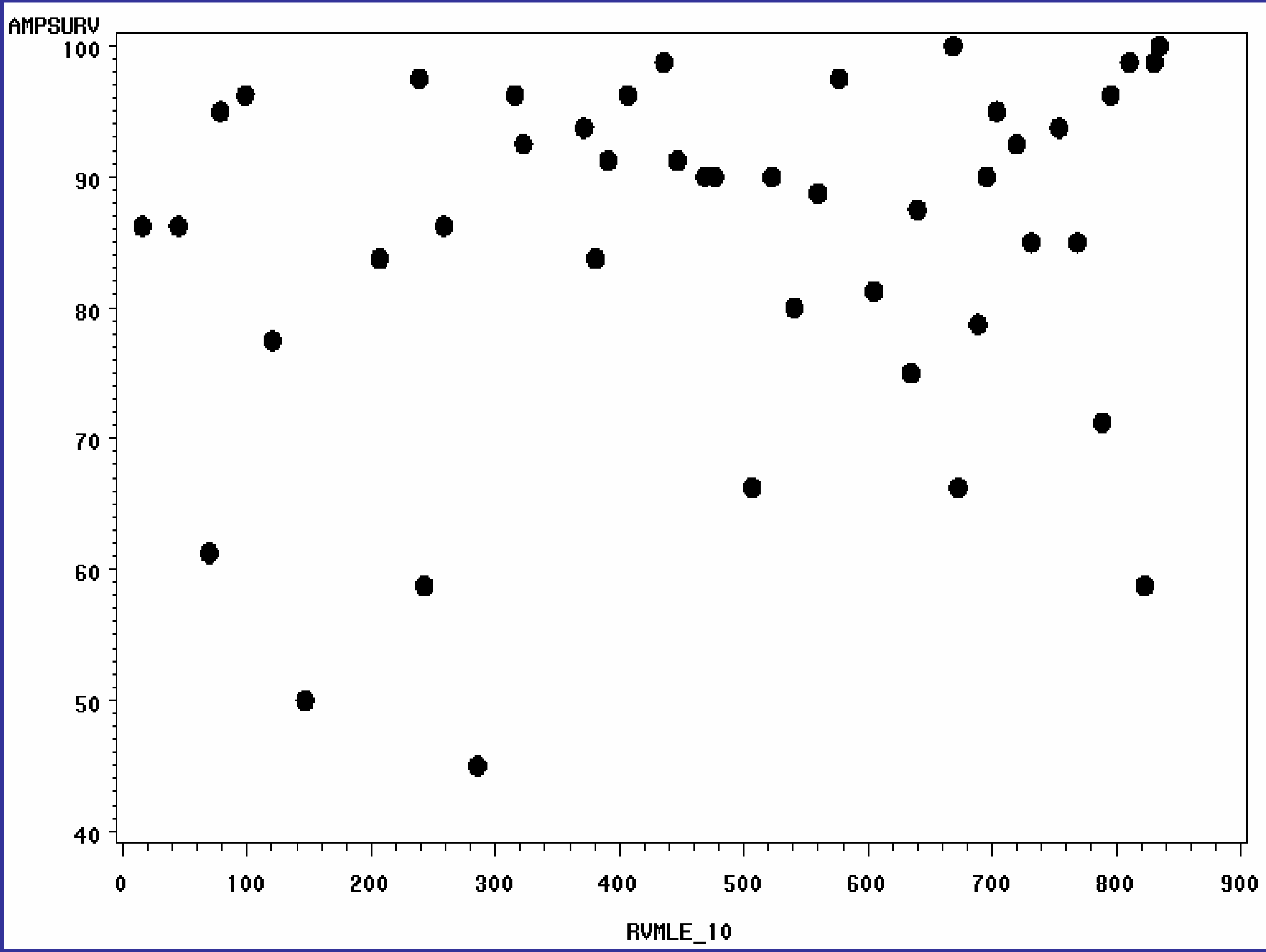
% local impervious surface



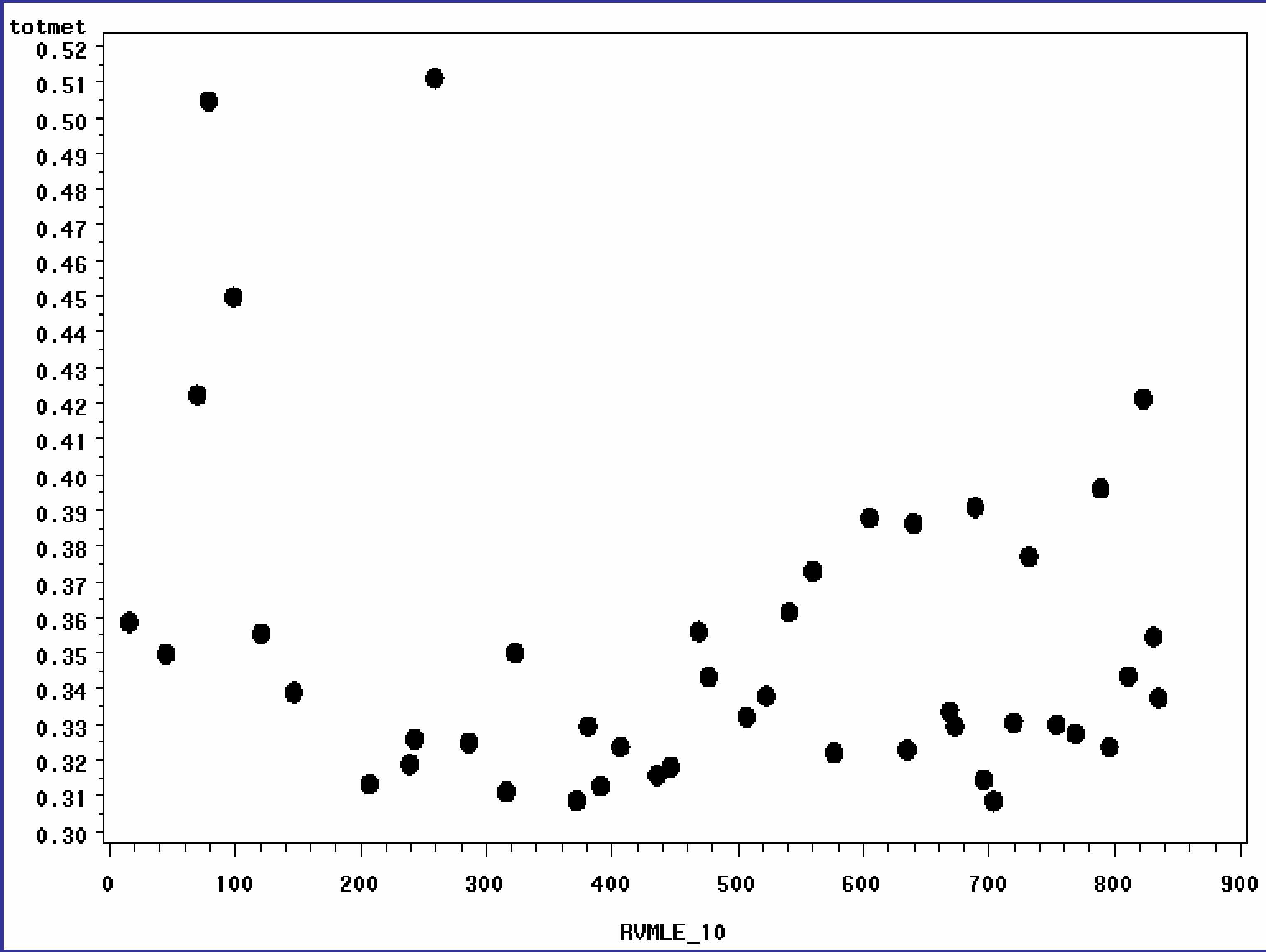
Turbidity


TURBIDITY
300
200
100
0
0
100
200
300
400
500
600
700
800
900
RVMLE_10
No local variation = bad metric?
Flow effect = bad metric?

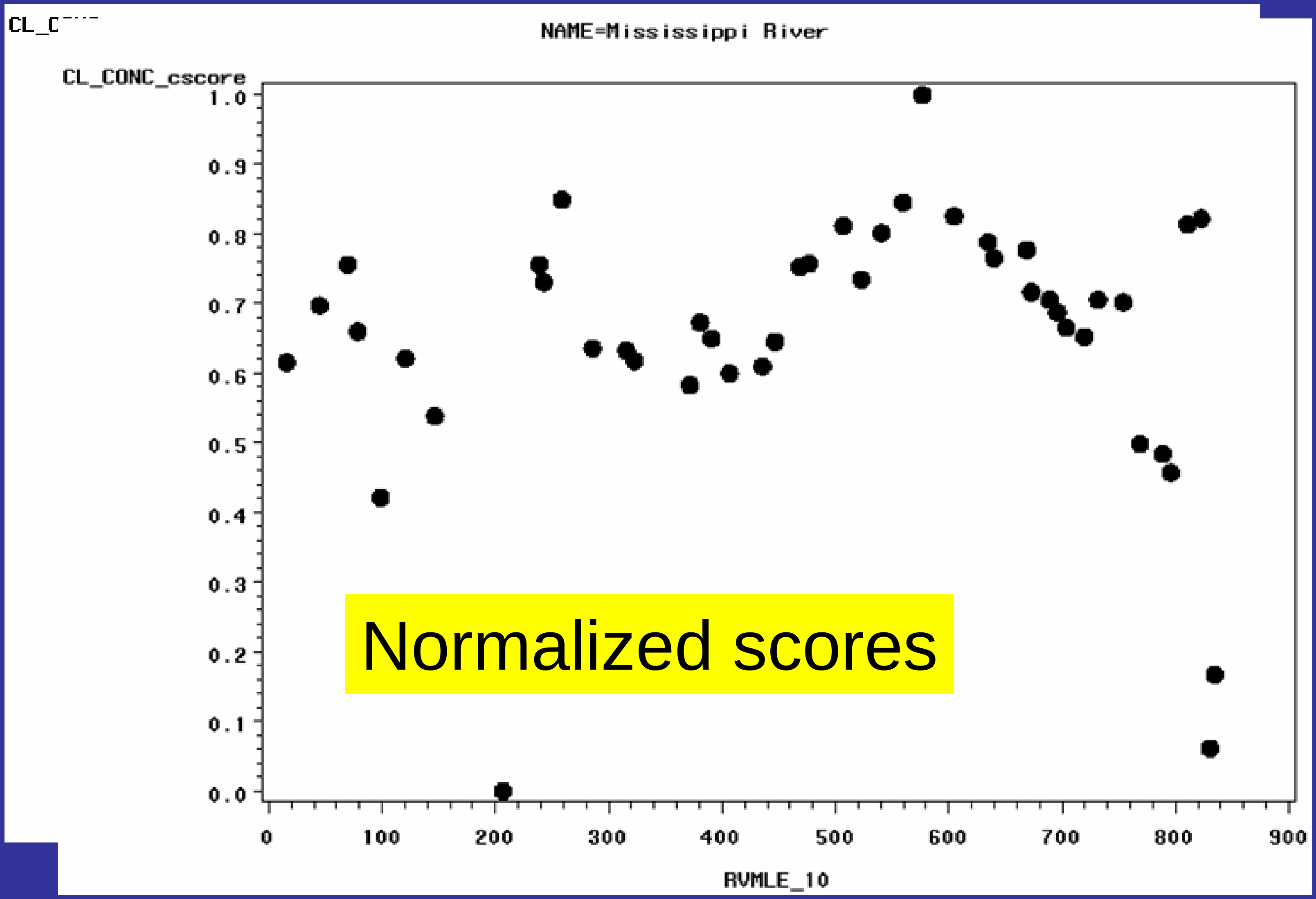
Sediment toxicity



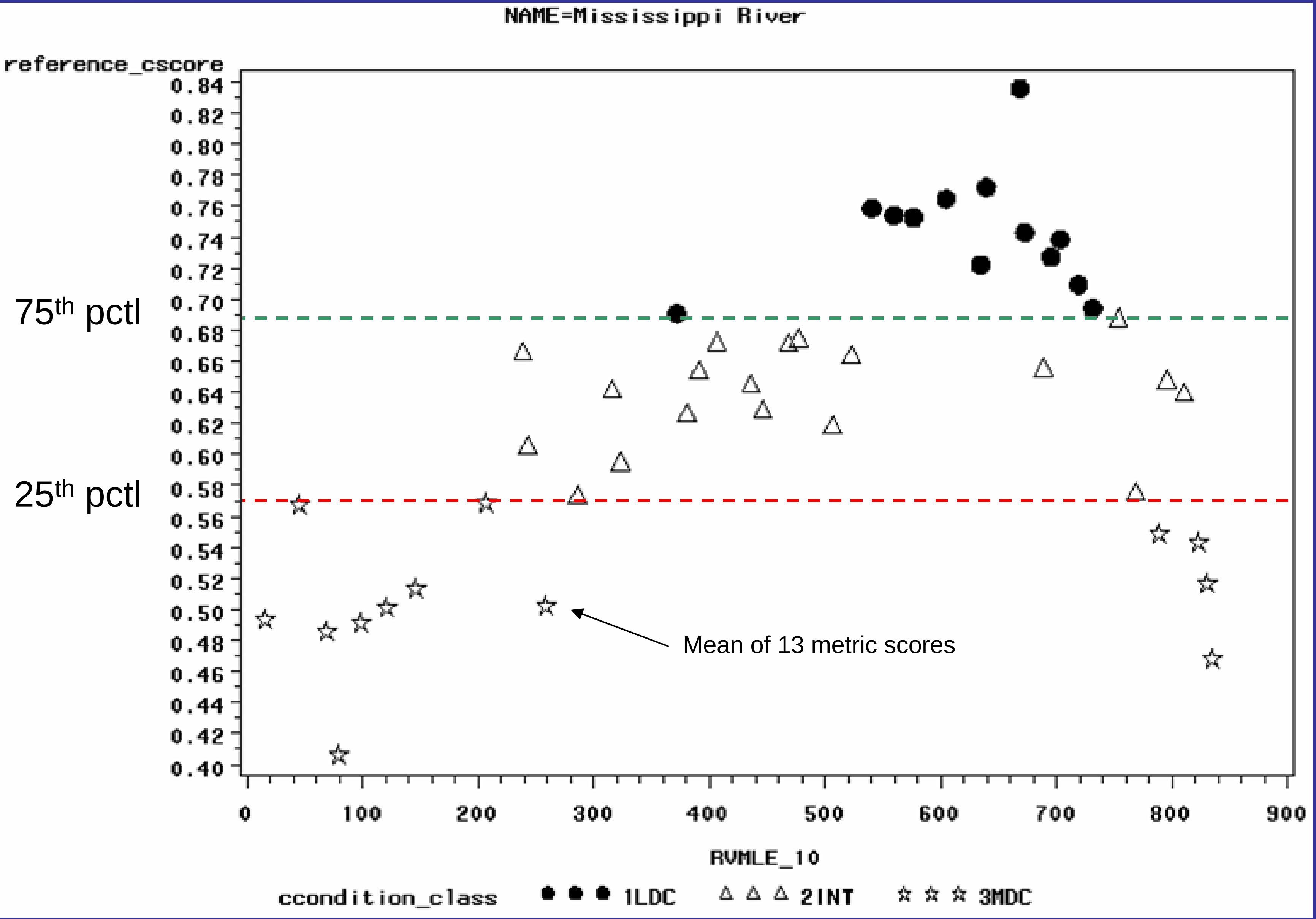
Dissolved metals



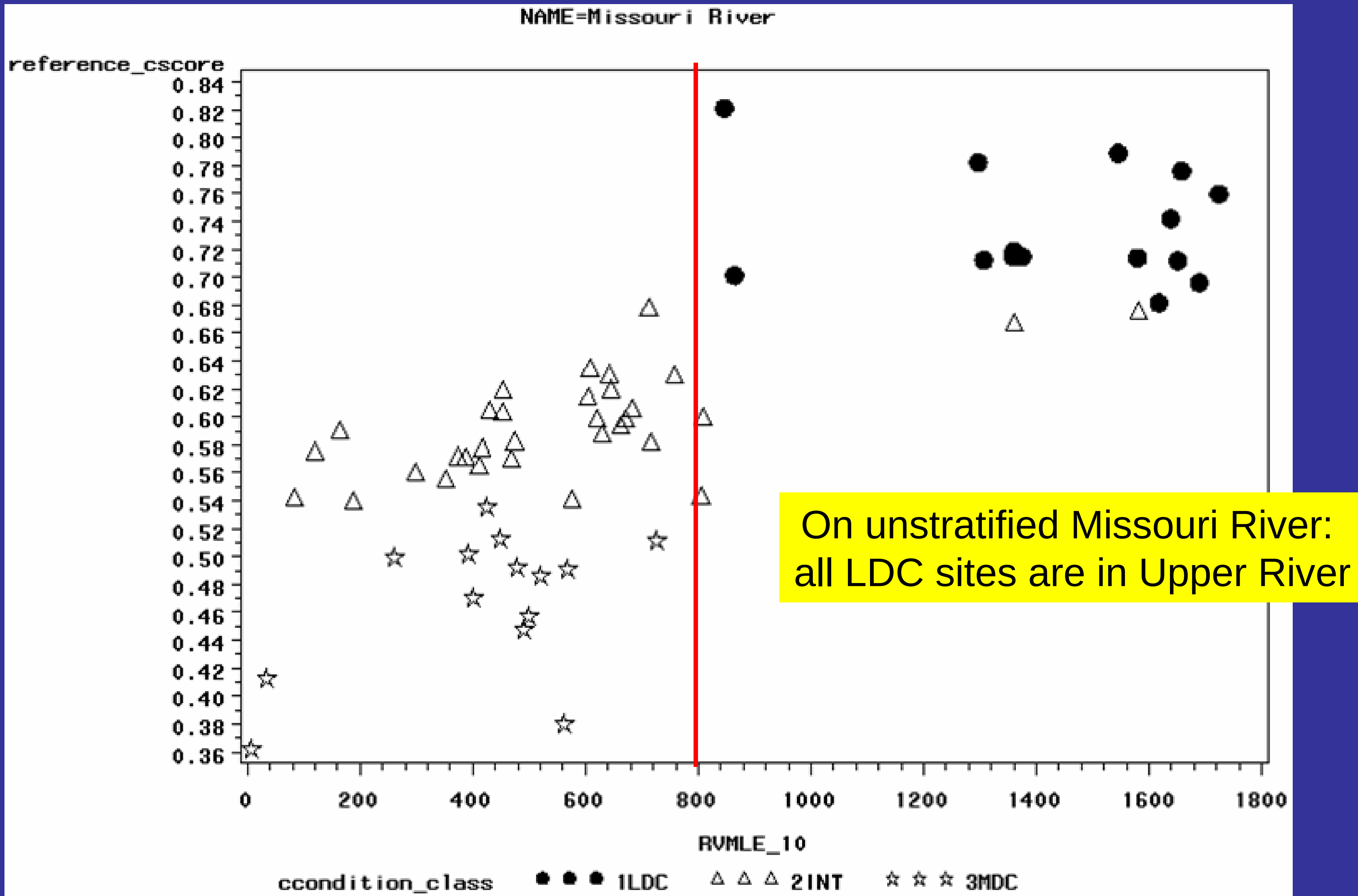
Chloride



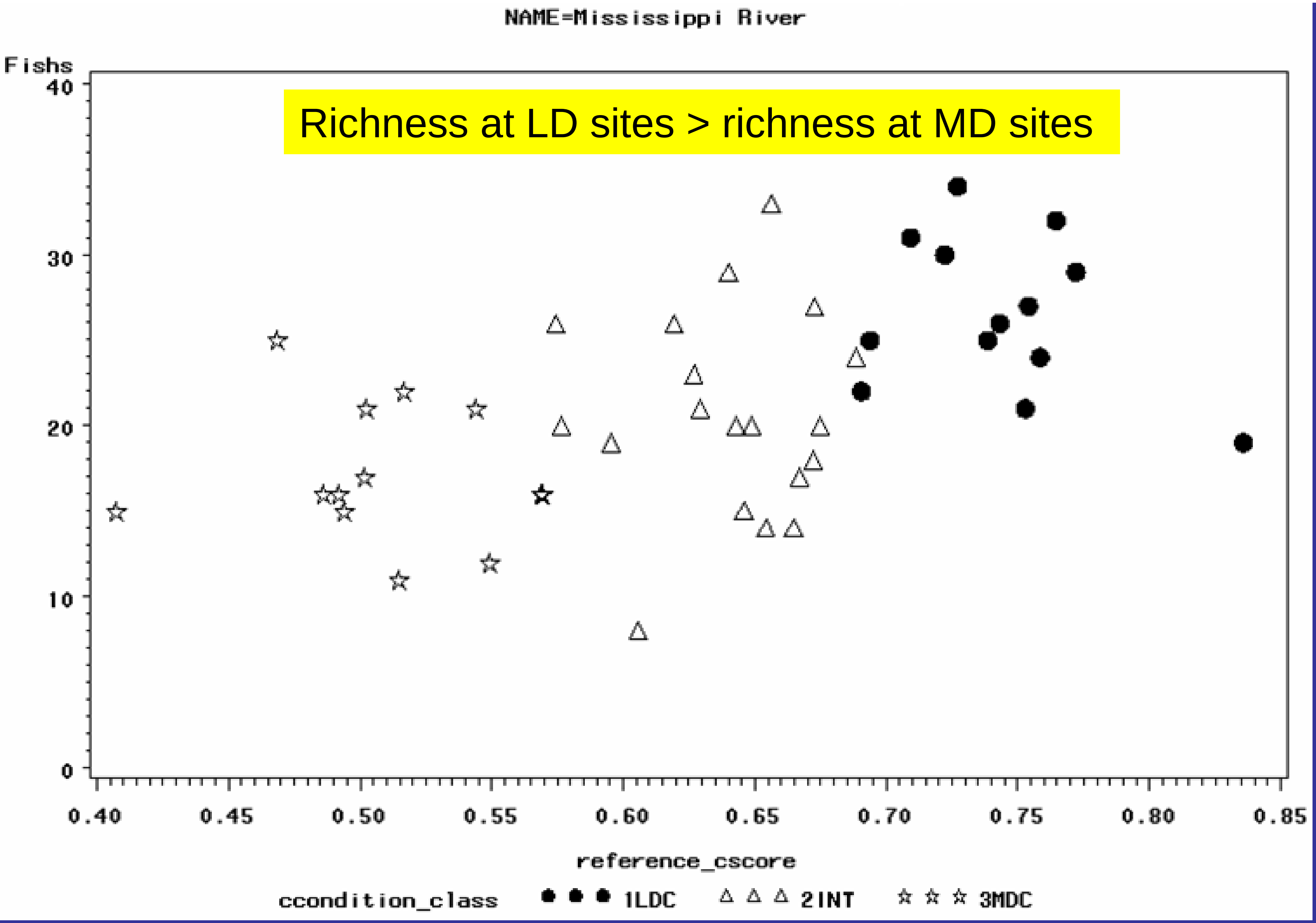
Normalize scores to 0 – 1



Compute mean scores for all sites –
Percentiles suggest condition classes



Percentiles suggest condition classes

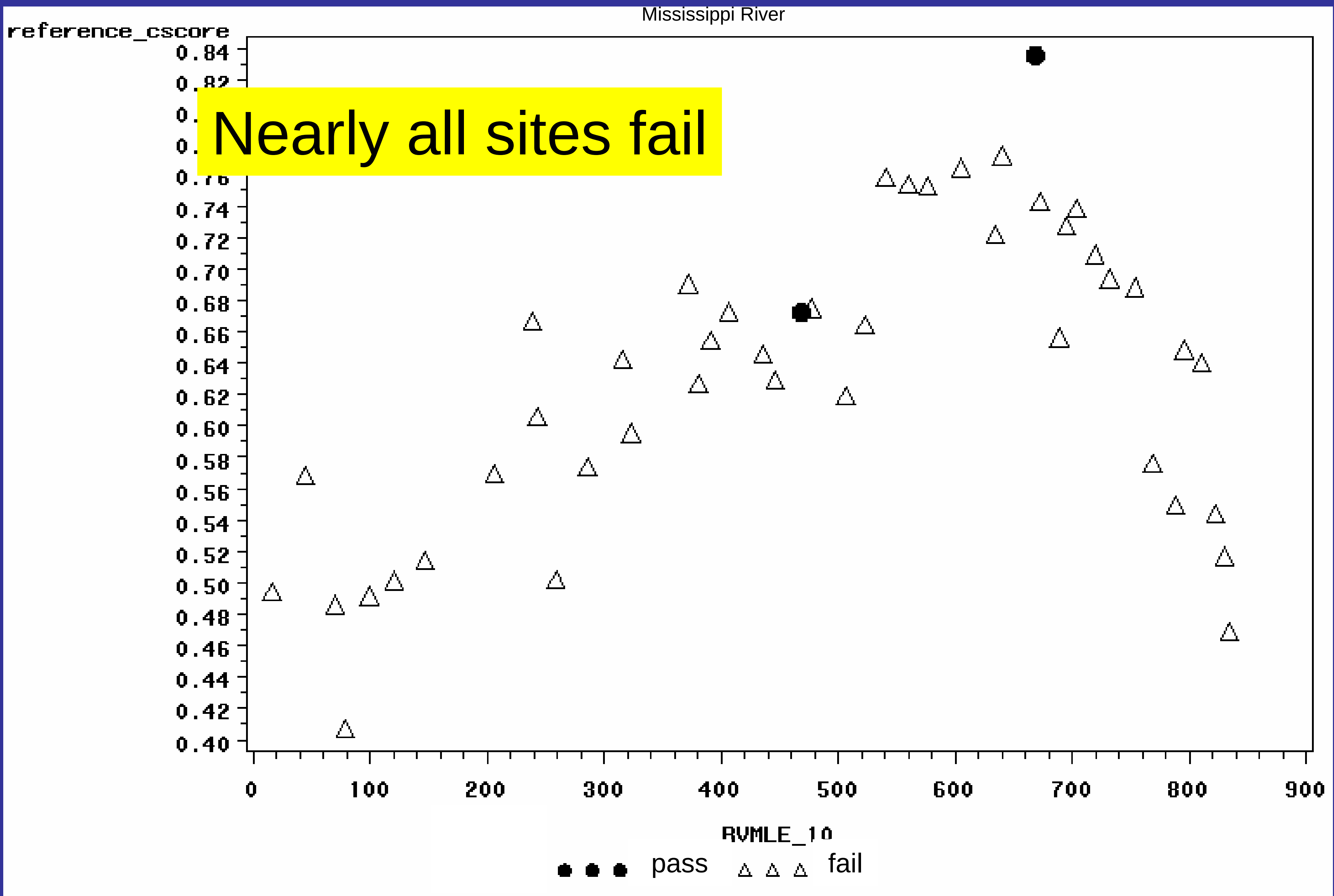


Test this particular model using native fish species richness

*This is not *the* model (metrics, criteria, percentiles) this is just one possible model from among many models.

P/F model test

- Same metrics as the multimetric test
- P/F criteria set by pctl for each metric:
- $\geq 75^{th}$ pctl (for pos metrics) = Pass
- $\leq 25^{th}$ pctl (for pos metrics) = Fail
- Pass all 13 = LDC; Fail any of 13= MDC



Mississippi River
reference_cscore
Nearly all sites fail
0.84
0.82
0.74
0.72
0.70
0.68
0.66
0.64
0.62
0.60
0.58
0.56
0.54
0.52
0.50
0.48
0.46
0.44
0.42
0.40
0
100
200
300
400
500
600
700
800
900
pass
fail

Conclusions

- There are no shortcuts. Screening will be an iterative process.
- We will try multiple screening approaches.
- The multimetric approach seems promising for GRE data.

Conclusions, continued

- Strong longitudinal patterns in condition are likely for all three rivers

- The 3 rivers are very different – likely to need different screening metrics and stratification schemes to optimize screening.

Mississippi River at New Orleans RM 94